The World Hologram

The Holographic Universe is Everett's Relative State

The Measurement Problem is a Category Error of Logical Type

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Abstract: The key to the measurement problem is the entity at the heart of Everett's formulation, the state of the memory, defined as the record of observations. In humans, the integrated synthesis defines the perceptual reality, a projective, three-dimensional representation of the world. This 'world hologram' is the conscious point of view, the mind in Lockwood's interpretation, the 'phenomenal perspective'. As Everett demonstrates, the collapse dynamics operates only judged by the state of the memory; the physical observer remains in a superposed state. An operational mind-body property dualism is defined.

This field of information is multiply instantiated in the many worlds of the unitary wave function. As these are superposed and coincident, the net result is a single world hologram. The physical frame of reference on this view is the superposition of the class of instantiating worlds, a second-logical-type phenomenon. By definition determinate only where defined by observations, this is the physical ontology of Everett's relative state. Collapse on observation is inherent.

The evidence is the retrodiction of the holographic universe. This is the cosmology of the relative state. As it is determinate solely where defined by the world hologram that delineates the outer boundary, entropy is defined solely by this surface. The quasi-classical world is the cosmology in the absolute state.

The incompatible dynamics of quantum mechanics operate in these two different types of physical frames of reference. The linear dynamics is the time evolution of the quasi-classical worlds. On observation, judged by the state of the world hologram, the class of instantiating worlds is redefined, becoming the class of worlds in which the observed outcome occurred. Collapse effectively operates. The holographic universe of the mind updates. The dynamics operate at different levels of logical type. The measurement problem is a category error.

1 Unmodified Quantum Mechanics

> Unmodified quantum mechanics has passed every empirical test we have been able to devise … In light of progress over the last four decades on the theory of decoherence, and of progress over the last two decades in understanding probability in the Everettian setting, EQM [Everettian quantum mechanics]—more than ever—appears to be the most natural way to understand contemporary quantum physics. … It is time to pay attention to its lessons in ontology. (Wilson, 2019)

Here it is shown that the dualism of the dynamics of quantum mechanics is due to the different types of frame of reference inherent in the physics. There is a dualism of ontologies, as evinced by the absolute and relative states in Everett's formulation. They exist at different levels of logical type in the unitary system. They operate the linear and collapse dynamics respectively. The measurement problem is naturally resolved by this explanation of the standard unmodified quantum mechanics.

It is clear that there are two very different types of frame of reference in the cosmology of the new physics, but the full significance has been elusive:

> … the development of relativity theory and quantum mechanics has taught us that we must carefully distinguish between two different views of a mathematical structure:
>
> - The *bird perspective* or *outside view*, which is the way a mathematician views it.
> - The *frog perspective* or *inside view*, which is the way it is perceived by a SAS [self-aware substructure] in it.
>
> (Tegmark, 1998, p. 23; emphasis in original)

The outside-view world follows solely the linear dynamics, producing all possible worlds: "... which are structurally and dynamically 'quasiclassical'" (Wallace, 2010, p. 70). This defines the absolute state. On the inside view, in the world of the SAS, the collapse dynamics is encountered. This is the nature of the relative state.

> There is only one wavefunction, and it evolves smoothly and deterministically over time without any kind of splitting or parallelism. The abstract quantum world described by this evolving wavefunction contains within it a vast number of classical parallel storylines ("worlds") … observers perceive only a tiny fraction of this full reality, and they perceive the splitting of classical storylines as quantum randomness. (Tegmark, 2007, p. 3)

Decoherence has been proposed as the explanation of collapse, but as described in Section 5 this is untenable. Thus the measurement problem remains unresolved, as does the preferred basis problem. The nature of the SAS is the key to the solution.

2 The World Hologram

The inside view of the world is the perspective defined by the information perceived. This is the perceptual reality that each perceiving subject experiences directly. In humans this takes the form of a virtual-reality representation of the world:

> Our brain constructs a three-dimensional model. It is a virtual reality in the head. (Dawkins, 1998, p. 276)

This is literally the inside view, the field of information, produced by the sensorium, that is directly experienced as reality:

> What we experience directly is a virtual-reality rendering, conveniently generated for us by our unconscious minds from sensory data (Deutsch, 1997, p. 120)

This is the nature of each observation made. The current three-dimensional rendering of the environment perceived is recorded in memory.

The integrated synthesis of the record of these observations forms the complete definition of the virtual-reality model. This is the known world of this individual, meaning the perceptual reality in its entirety. This is the virtual-reality representation of the whole of the world known from observations. This is the field of information in operation when considering situations elsewhere. This is the mind in Lockwood (1996), the conscious point of view, the 'phenomenal perspective'.

As Deutsch goes on to describe, quoted in Section 11, this three-dimensional virtual-reality representation is mentally projected onto the physical world so as to match up precisely. This is here called the world hologram, meaning the spatially distributed representation of the integrated synthesis of the record of observations.

Counterintuitively, this subjective information is key to the dynamics of physical science. The record of observations is the definition of the state of the memory, the core component of Everett's formulation. As he demonstrates it is only “Judged by the state of the memory” (1957, p. 462) that there is the effect of collapse, 'Process 1':

> It is found that experiences of the observer … are in full accord with predictions of the conventional "external observer" formulation of quantum mechanics, based on Process 1. (1957, p. 455)

As will be shown, the integrated synthesis of the experiences completely defines the SAS on the inside view. The terms world hologram, mind, individual and perceiving subject are here used interchangeably for this protagonist of Process 1. The term observer is used exclusively for the physical body, the machine that makes observations: “... a recording device” (Everett, 1957, p. 457). Objectively, the observer is the obvious definition of a self-aware substructure, but here the terms

self-aware substructure or SAS are used exclusively to refer to the world hologram.

3 The Metaworld

The physical reality of the world hologram demonstrates the ontology of Everett's relative state. As Tegmark (2003) describes, there is inevitably a great number of identical copies of a specific observer in the universe. Thus a specific world hologram is multiply instantiated. In the many-worlds universe, the instantiating worlds are coincident and superposed: “Reality is a superposition of all possibilities” (Cox, 2017). In this case there is only a single instance of this specific world hologram: identical and coincident copies of a structure of information cannot be other than a single instance. Therefore, not only is this the inside view of all these worlds simultaneously, crucially, the physical environment on this view is their superposed sum. The net result is a 'class-of-worlds-as-a-world', literally a metaworld. This is the quantum-mechanical frame of reference of the inside view.

Only what has been observed is determinate because only the observed is the same in all the different versions of the quasi-classical world superposed. All else is the superposition of all the possible states in which it could be, concomitant with the world hologram. Thus this type of physical reality is determinate solely where defined by the record of observations. This is the physical reality of the relative state, determinate only where correlated with the SAS by the observations made.

This explains the dynamics of the relative state. As the physical environment is determinate only where defined by the world hologram, the effective collapse of the wave function described by Everett is inherent. Naturally, the making of an observation only changes the definition of the world hologram, the internal representation of the world of the protagonist. The missing explanatory principle is that this changes the definition of the class of worlds that instantiate this world hologram, to all those in which this specific observation was just made.

This is the collapse dynamics. It is a set-selection phenomenon. The record of observations is the basis on which worlds are included in the class of worlds superposed to form the metaworld. Schrödinger's (1935) cat is an ideal example. A cat in a chamber has a 50-50 chance of being killed by a quantum device. Before the experimenter observes the result, his class of superposed worlds subsumes two different classes of worlds, dead-cat and alive-cat. After, only half these worlds are included in his metaworld, the class in which one specific outcome occurred. His physical reality becomes one of the two resulting relative states.

The paradox of Schrödinger's cat arises because of the assumption of a specific quasi-classical world as the domain of the experiment. As Russell (1908) demonstrated, category errors of logical type inevitably produce nonsense results and paradox. This is the origin of the absurdity that Schrödinger illustrates. Logically, dead and alive can only be a second-logical-type phenomenon.

4 The Measurement Problem

> … if one supposes that measuring devices are ordinary physical systems just like any other, constructed of fundamental particles interacting in their usual determinate way (and why wouldn't they be?), then the standard theory is logically inconsistent since no system can obey both the deterministic and stochastic dynamics simultaneously. This is the measurement problem. (Barrett, 1999, p. 15)

The solution is that these are the dynamics of different types of frame of reference. Naturally, physical measuring devices can follow only the linear dynamics of the absolute state. However, as Everett (ibid) demonstrates, it is not the measuring device that is the protagonist of the collapse dynamics but its product, the record of observations. He resolves the measurement problem by showing that collapse occurs only with respect to this protagonist, i.e. in the relative state. Thus the incompatible dynamics operate simultaneously in the absolute and relative states.

As Everett describes, the linear dynamics is the sole causal process. Collapse is a subjective epiphenomenon of the linear dynamics. As he shows, it is the "... *subjective* appearances" (1956, p. 9; emphasis in original) that account for the stochastic dynamics. However, with no ontology defined it seems his explanation must fail:

> … it is a fundamental requirement of the scientific viewpoint - the so-called principle of the psycho-physical parallelism - that it must be possible so to describe the extra-physical process of the subjective perception as if it were in reality in the physical world - i.e., to assign to its parts equivalent physical processes in the objective environment, in ordinary space. (von Neumann, 1955, p. 418)

As Barrett demonstrates in meticulous and exhaustive detail, it is not possible to find a physical process in the objective physical environment that corresponds to the single unique outcome of an observation in the experiences of the observer that Everett describes. In other words, subjective experience cannot account for collapse.

This, however, is true only on the outside view. On the inside view there is the effect of collapse as Everett states. This is the result of the set-selection phenomenon that redefines of the class-of-worlds-as-a-world, and thus its wave function. This extra-physical process cannot be described in the objective environment because it is a second-logical-type phenomenon. Rather, it means that actual psycho-physical parallelism is a one to many relation: world hologram to class of worlds.

In the extra-physical domain of the metaworld, the relative state, this extra-physical process is ontic. Collapse is a subjective epiphenomenon of the linear dynamics, but on the inside view this redefines the composition of the physical

Figure 1: Fission of the relative state on observation.

reality, and thus its quantum state. Effectively, in this second-logical-type world, collapse of the wave function operates. A dualism of ontologies is defined.

5 Unilateral Ontological Dualism

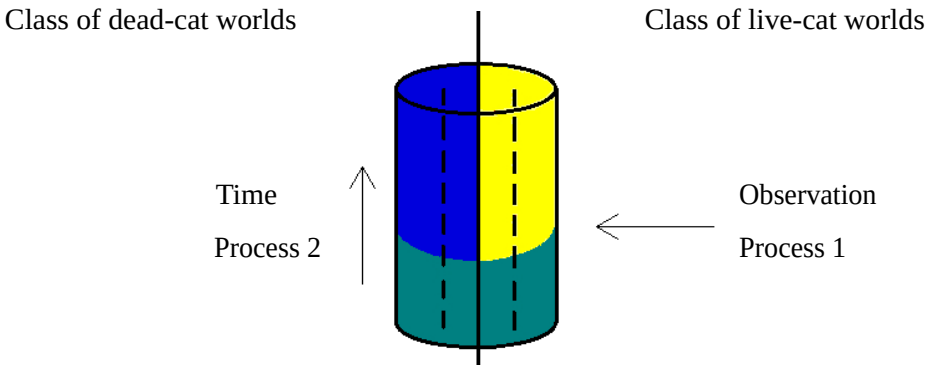
On the outside view the world hologram that defines the inside view is defined by the physical form in which it is instantiated. The physical is ontic. On the inside view, however, this information is ontic both with regard to the definition of physical reality and its time evolution. There are dual unilateral relative onticities:

> The central point of the concept of relative onticity is that states and properties of a system, which belong to an epistemic description in a particular domain, can be considered as ontic from the perspective of another domain. (Atmanspacher & Primas, 2005, p. 19)

This resolves the quantum puzzle. Passive observation altering the objective physical reality is an obvious nonsense result. The problem is not the physics but the presupposition of a quasi-classical world. The incompatible dynamics operate at the different levels of logical type. They cycle as defined in the von Neumann-Dirac formulation (1955). ψ is the wave function of the class-of-worlds-as-a-world:

> Process 1: The discontinuous change brought about by the observation of a quantity with eigenstates φ1, φ2, , in which the state ψ will be changed to the state φj with probability $|(\psi, \varphi j)|^2$.
>
> Process 2: The continuous, deterministic change of state of an isolated system with time according to a wave equation $\partial\psi/\partial t = U\psi$, where U is a linear operator.

Process 2 is the linear time evolution of the superposition of worlds comprising the relative state. Process 1 is the fission of the relative state into multiple relative states. Each probability represents the quantity of worlds containing a specific outcome. Figure 1 (Lockwood, 1989, p. 231; adapted) illustrates the time evolution of the class-of-worlds-as-a-world of the Schrödinger's cat experimenter. Process 2 is progression up the diagram. Process 1 is the differentiation into two relative states.



6 The Preferred Basis

The paradigm shift to a dualism of ontologies seems supererogatory if the view is taken that decoherence resolves the problem. This, however, does not work as Bacciagaluppi describes in *The Role of Decoherence in Quantum Mechanics*:

> One often hears the claim that decoherence solves the measurement problem of quantum mechanics … it is not the case: while decoherence *does* explain why we do *not* observe superpositions of measurement results, it does *not* explain why we *do* observe measurement results in the first place. … To put it crudely: if everything is in interaction with everything else, everything is generically entangled with everything else, and that is a worse problem than measuring apparatuses being entangled with measured systems. (2020; emphasis in original)

Furthermore, the basis on which decoherence operates, how exactly the world is defined, remains unresolved. This is the preferred basis problem:

> … this is the problem, we do not really know what basis would make our most immediately accessible physical records, those records that determine our experiences and beliefs, determinate in every world. The problem of choosing which observable to make determinate is known as the preferred-basis problem. (Barrett, 2008)

Naturally, taking the records of experiences themselves as the basis in operation resolves this problem. This is Lockwood's solution. This: "… in a sense is the *primary* observable" (1996, p. 185; emphasis in original).

Experimental confirmation of Wigner's (1961) friend provides the evidence. Wigner's friend makes an observation with a determinate result, but for Wigner the outcome is indeterminate. Their physical realities are different relative states:

> … Massimiliano Proietti at Heriot-Watt University in Edinburgh and his colleagues performed an experiment designed by Brukner and tested Wigner's Friend Paradox by entangling six photons. They proved that two contradictory realities could coexist. Eugene Wigner was right; the quantum reality is observer-dependent. (Poltorak, 2019)

Nonetheless, a physical basis is self-evident, hence the quasi-classical worlds: "... classical states are simply those that are most robust against decoherence" (Tegmark, 2003, p. 9). This is the basis of the physical reality on the outside view:

> Essentially, the position basis gets singled out by the dynamics because the field equations of physics are local in this basis, not in any other basis. (Tegmark, 1997, p. 3)

The preferred basis problem is resolved by the dualism of ontologies. The basis in operation is different on outside and inside views, hence the different dynamics.

7 The Holographic Universe

The evidence of this dualism is the precise retrodiction of the holographic universe, and thus the dualism of operational physical cosmologies:

> What's happening in space is, in some sense, all described in terms of a screen outside here. The ultimate description of reality resides on this screen. (Dijkgraaf, 2019)

This is the physical reality of the metaworld. The intersection of the class of worlds superposed – the only attribute of the world common to all – is the observed surface. So this surface, the 'screen', is the only determinate attribute of the physical reality.

In the strong version, the holographic principle means that in effect there is nothing there beyond the surface; in the weak version the screen is all there is:

> … the holographic principle states that the most succinct description that can be given of the part of the world that lies on the other side of any surface is actually a description of how its image evolves on that surface. … The problem is that it describes the world in terms of things.
>
> … we are mistaken to think that the world consists of Things that occupy regions of space. Instead, all that there exists in the world are Screens, on which the world is represented. (Smolin, 2000, p. 177)

The evidence for the weak version is that the entropy of ordinary mass is proportional to surface area and not volume, as Bekenstein describes, which would mean that:

> … volume itself is illusory and the universe is really a hologram which is isomorphic to the information "inscribed" on the surface of its boundary. (2003, p. 59)

The paradoxical nature of the holographic universe lies in conceiving of the quantum cosmology as a surreal description of the quasi-classical world. The effect is

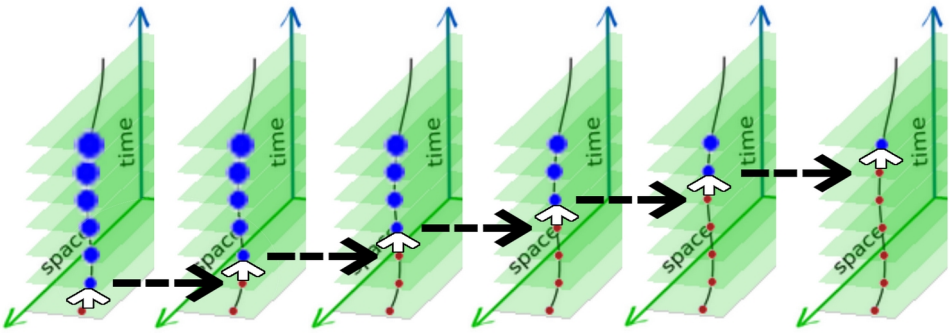


Figure 2: A sequence of quantum mechanical frames of reference.
(The diagram is eternalism. The arrows are presentism. The red dots are possibilism.)

natural and inherent in the metaworld of the relative state, a second-logical-type phenomenon. This is indeterminate except for the intersection of the class of worlds superposed, the observed surface, thus the entropy is entirely defined by this boundary. The holographic universe is not a surreal spherical causal shell at the outer limit of the cosmos but just the observed surface of the physical environment.

Effectively, the relative state is made of information as proposed by Wheeler (Bekenstein, 2003, p. 1), but physicalism is correct also, for each quasi-classical world. The metaworld is a superposition of quasi-classical worlds, each one a three-dimensional volume of the arrangement of matter and energy. This is the physical reality of Everett's relative state. The holographic universe describes the net effect with precision but this is nonetheless a real physical world. Volume is not illusory.

8 Micro/Macro

> It's always bothered physicists that there is one set of rules for the microcosmic, quantum mechanics, and another for the macrocosmic, the theory of relativity. It doesn't make sense that there should be two different and incompatible groups of mathematical formulas at work in our universe. Physicists assume there must be some way to bring them into harmony. (Goodman, 2018)

As he describes, different units of information, and different forms, define the cosmologies of the world of relativity and the holographic universe. The building blocks of relativity are ordinary units of information, 'bits', which exist in three dimensions. This is the domain of the linear dynamics. As Tegmark (ibid) states, the position basis gets singled out. Taking position as the basis, the linear dynamics defines the time evolution of the three-dimensional, x, y, z, layout of matter and energy, with respect to the time parameter t. Thus the formula of the linear dynamics defines the four-dimensional, x, y, z, t, space-time matrix of the matter and energy events in the relativistic universe. This defines the quasi-classical relativistic world.

The building blocks of the holographic universe in quantum cosmology are quite different, 'qubits', units of quantum information. Qubits exist in two dimensions. Each qubit is a complex vector defined by two ket values, resulting in a range of possible indeterminate values. As they are flat, the qubit description of the world forms a zero-depth surface at the boundary, hence the form of the holographic universe as he explains. The great puzzle is how to integrate the two, building up macro from micro and thus deriving the macroscopic cosmology from the quantum cosmology.

It works the opposite way. Superposed quasi-classical relativistic worlds form the class-of-worlds-as-a-world. This gives rise to the effect of the holographic universe of quantum cosmology. The intersection of the class of worlds superposed is the observed surface, which is defined by the world hologram. Since this is the only net information in the system, the quantum information defines the observed surface of the environment. As the value of a qubit changes depending on the value of its entanglements, the system changes holistically with the addition of each new correlation established. Collapse operates. The stochastic formula applies.

The unilateral ontological dualism of the absolute and relative states lays to rest the micro/macro puzzle. The distinguishing parameter is not scale but the logical type of the physical frame of reference. The relativistic quasi-classical universe is a specific attribute of the absolute state. The holographic universe is a relative state, a second-logical-type phenomenon. The incompatible formulas are those of these different types of frames of reference. They enact different operational principles, hence the different cosmologies.

9 Perpendicular Times

The ontological dualism accounts for the two different types of time in the new physics. In relativistic physics, other times are other moments in space-time. In the quantum concept of time: “Other times are just special cases of other universes.” (Deutsch, 1997, p. 278). As he describes, each universe is a 'snapshot' of the physical state of the whole world, defined by a specific quantum state: a point in Hilbert space.

Each snapshot defines a specific space-time array of matter and energy events, the x, y, z, t layout of the linear dynamics, as symbolised by each space-time worldline image in Figure 2. With respect to the inside view each snapshot is that of the metaworld of the SAS, a holographic universe. The two types of time cycle as described in the standard von Neumann-Dirac formulation.

The linear dynamics operates within the context of a specific snapshot. Within this frame of reference the definition of the positions and states of physical elements change with the advance of the time parameter, as the wave function dictates. The effect is the movement of the viewpoint of the SAS along the world-line into the future, as symbolised by the white arrows: the time evolution of the inertial frame of reference. This is experienced as the passage of relativistic proper time.

The expanding blobs symbolise the growing quantum indeterminacy. At the point in time where an observation is made the world hologram changes, thus the SAS is defined as existing in a different metaworld. As shown in Figure 1, it becomes the metaworld in which this event has determinately happened. Thus the viewpoint passes to a different snapshot as shown by each black arrow. This is a different type of phenomenon to the linear dynamics, operating in the quantum state space: “... a new dimension running, so to speak, perpendicular to time and space.” (Lockwood, 1989, p. 232). Effectively, in the progression in quantum time, the quantum state changes and the wave function collapses. This is experienced as events happening.

10 The Mind

The concept presented here proffers the ontology for Lockwood's (1996) many-minds explanation of Everett. The world of each mind, the relative state, is defined by the correlations established by observations as Everett describes. The missing key is that correlation with the SAS defines an entire class of worlds.

Lockwood's definition of the mind is different to the common usage of the word, generally taken to mean all the information processing attributes of the brain. It is solely the subjective component which he calls the phenomenal perspective, also a 'maximal experience' and 'a complete state of consciousness'. Here this subjective component, the reality of the sensorium, is defined as the world hologram. The rest of the mind as conventionally defined is taken to be the self-management system that operates in the neural network of the observer machine. This is here considered to be the operating system of the hardware of the physical body.

The phenomenal perspective, the world hologram, is the product of a specific subsystem of the operating system. This is what Block calls 'access consciousness', which he defines as the answer to the question: “What makes neuronal representations available for thought, decision, reporting and action?” (2003, p. 8). This is the operational subsystem that produces the perceptual reality in real time. The world hologram is the cumulative product of access consciousness, the known world. This integrated synthesis of everything known is the basis on which the thought, decision, reporting and action of the individual operate.

As with the physical reality generally, the body is only determinate where observed. The many bodies that instantiate the world hologram, in the class of worlds superposed, include every possible variation of physical definition concomitant with the world hologram. Thus only that which this defines is determinate because all else is the superposition of all possible variations.

This means that the state of the neural operating system of the hardware is also indeterminate except where observed. In the many-worlds universe:

> … any particular state of consciousness should be consistent with a large number of computational states. (Mitra, 2012, p. 4)

As with the body, the state of this information processing system is the superposition of all the possible states it could be in, concomitant with the world hologram.[1]

1 As Tegmark (1999) describes, it is not possible for the physical brain to act as a quantum computer, but in the metaworld such a phenomenon appears inevitable. On the inside view it is a class-of-brains-as-a-brain, and thus it is operating all possible versions of its computations in superposition. If the SAS can be shown to achieve results that could not possibly be the result of standard neural functioning, this could stand as evidence. Thus the concept of the metaworld is potentially testable.

11 The Self-Avatar

Everett's formulation categorises two classes of observations, external and internal. He defines the observer as a machine, a device that records: “... sensory data and machine configurations” (1957, p. 457). In humans, the integrated synthesis of the sensory data forms the world hologram, the three-dimensional real-time representation of the world. The integrated synthesis of the machine-configuration data forms the three-dimensional real-time representation of the self at the centre, the 'self-avatar'.

The term self-avatar is used here to mean the integrated synthesis of all the observations of the self, the complete mental construct produced over time. This includes the self-concept, the self-image and the body schema. All together this forms the known self. This is a three-dimensional virtual-reality construct at the centre of the world hologram, the real-time representation of the whole of the self as known to the self.

The immediate experiences of the body through proprioception and enteroception form the direct observations of machine configuration. The integrated synthesis forms the internal aspect of the avatar, the body schema. External observations of the self form the socially-facing physical self-image, the external form of the avatar. Thoughts, feelings and emotions are the observations of the overall state of the neural network and the endocrine system that form the psychological self-concept.

As with the rest of the world hologram, the self-avatar at the centre is precisely projected onto that which it represents, the three-dimensional body of the observer at the centre of the perceived world. As Deutsch describes:

> Consider the nerve signals reaching our brains from our sense organs. Far from providing direct or untainted access to reality, even they themselves are never experienced for what they really are – namely crackles of electrical activity. Nor, for the most part, do we experience them as being *where* they really are – inside our brains. Instead, we place them in the reality beyond. We do not just see blue: we see a blue sky up there, far away. We do not just feel pain: we experience a headache, or a stomach ache. The brain attaches those interpretations – 'head', 'stomach' and 'up there' – to events that are in fact within the brain itself. (2011, p. 10; emphasis in original)

Thus all experiences of the body's sensations are actually the projected experiences of the neural definition of the self-avatar figure. In other words, the body directly experienced is the self-avatar, a field of information generated by the brain. As all else is indeterminate this is the only determinate identity on the inside view, as described in the next section. Naturally, the familiar definition of human identity is

nonetheless the correct one on the outside view, the physical entity as a whole.

12 The Functional Identity

> If I am the agent, the objective world is everything outside my mind—including other agents and even my own body. All of that I may, if I chose, treat quantum mechanically and describe by wave-functions. (von Baeyer, 2016, p. 154)

The metaworld provides the ontology. On the inside view the body is indeterminate except where observed, and the same is true of the system of intelligence that operates the body outside of conscious awareness. The mind, the world hologram, defines the only determinacy.

The whole of the functional identity is defined in the world hologram, including the character. As Everett states of the physical observer, defined as an autonomous machine, the functionality is defined in the state of the memory:

> … the actions of the machine at a given instant can be regarded as a function of the memory contents only, and all relevant experience of the machine is contained in the memory (1957, p. 457)

Naturally, the decision-making capability of the observer is contained in the memory, the record of observations because this is the repository of the data produced by the access consciousness for this purpose, as Block (ibid) describes.

By definition, all categories of conscious mental experience operate in the virtual-reality representation of the world. As Deutsch describes:

> Every last scrap of our external experience is of virtual reality. And every last scrap of our knowledge — including our knowledge of the non-physical worlds of logic, mathematics and philosophy, and of imagination, fiction, art and fantasy — is encoded in the form of programs for the rendering of those worlds on our brain's own virtual-reality generator. (1997, p. 121)

On the inside view these programs are determinate only where their effects are observed, thus again the only determinacy is defined by the world hologram. This therefore defines all the attributes of the functional identity, such as experience, beliefs and criteria, and the habitual thoughts, behaviours, routines and practices.

The world hologram defines both the functional identity in operation and the determinacy of the physical body. This is the whole of the definition of the autonomous self-aware substructure in reality on the inside view. Objectively, the world hologram is a vital but minor part of the organism, the whole trillion-cell physical entity with its sophisticated neural system. On the inside view, however, the world hologram defines the whole of the determinacy of the conscious individual, the perceiving subject.

13 The Unconscious

The three levels of the human psyche in Jung's (1969) classification are also clearly distinguished. The conscious mind is the immediate awareness of experience, meaning the current image in the virtual reality. This is the observation being experienced at each moment, as it is added to the record of observations. The rest of the world hologram is the 'personal unconscious' in Jung's classification quoted below: the contents once in consciousness that have been forgotten or repressed. This is the record of observations, the recorded experiences not in immediate conscious awareness, including all the attributes of the mind so defined. The operating system of the body external to the world hologram defines the rest of the human psyche, and this corresponds to the 'collective unconscious':

> The collective unconscious is a part of the psyche, which can be negatively distinguished from a personal unconscious by the fact that it does not, like the latter, owe its existence to personal experience and consequently is not a personal acquisition. … This collective unconscious does not develop individually but is inherited. It consists of pre-existent forms, the archetypes. (1969, p. 43)

This is outside of the mind, part of the objective world in von Baeyer's dictum. This explains the profound difference between personal and collective unconscious. On the inside view only the former is determinate because the latter is indeterminate.[2]

As Jung describes, the human psyche embodies three distinct cybernetic layers. The conscious mind is the identification with the immediate awareness, the current observation, and the ego, the known self. The rest of the world hologram is the personal unconscious of the mind, the major part of the purely individual psyche on the inside view. The collective unconscious is outside the individual identity, thus not part of the mind, a locally-hosted attribute of the human cultural phenomenon.[3] This embodies the intelligence of the operating system of the physical organism that generates the world hologram, along with managing many other functions.

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2 Dennett (1991) proposes a 'multiple drafts' theory of mind, potential trains of thought running in parallel in the unconscious. In the metaworld all possible drafts must be present in the class-of-brains-as-a-brain, the effective quantum computer. Mental creativity is explained as a natural internal interplay between the order of the known world and the chaos of all possible thoughts and ideas superposed.

3 It is so named because this psychic component is shared among all beings of the same species. Thus members of a species share not only DNA but also certain 'archetypes', universal psychological traits developed over evolutionary periods of time. Observing the demagogic politics of the 1930s, Jung compared mass political movements to mass psychoses in which people uncritically channel these unconscious archetypes, which are being directly manipulated outside of conscious awareness. Here we see that all this is literally outside of the SAS, the conscious individual on the inside view.

14 The Missing Subject

The great paradoxes arise because of the exclusion of the perceiving subject from the physics. An entire type of frame of reference is missing from the science:

> The leading interpretations of quantum theory introduce concepts that are extrinsic to its equations (“observers”), or even contradict them (“collapse of the wave function”). The relevant literature is famously contentious and obscure. I believe it will remain so until someone constructs, within the formalism of quantum mechanics, an "observer," that is, a model entity whose states correspond to a recognizable caricature of conscious awareness; and demonstrates that the perceived interaction of this entity with the physical world, following the equations of quantum theory, accords with our experience. That is a formidable project, extending well beyond what is conventionally considered physics. I assume, perhaps naively, that this project can be accomplished, and that the equations will survive its completion unscathed. In any case, only after its completion might one legitimately claim that quantum theory is defined by the equations of quantum theory. (Wilczek, 2000)

This is Everett's protagonist, here the world hologram. It certainly accords with our experience: it is the conscious awareness, the phenomenal perspective.

Wilczek's "observer" is a physical entity, a class-of-bodies-as-a-body, but the net result is their intersection, a mind. Thus the functional identity of this entity is a field of information. The interaction of this "observer" with the environment follows both equations of quantum theory as Everett explicitly concludes, quoted in Section 2.

The equations are unchanged. The superposed bodies of the "observer" follow the linear equation of the absolute state. As each observation is made, this changes the definition of the "observer", and this changes the class of instantiating worlds, a second-logical-type set-selection phenomenon. The effective collapse of the wave function is experienced. As Lockwood (1989, pp. 230-2) describes, adapting Deutsch (1985), the stochastic probabilities arise from the percentage of worldlines that contain the various outcomes for this mind. Thus on the inside view the Born (1926) law operates. The body and the mind of the "observer" operate the two dynamics in their different domains, quasi-classical world and metaworld.

The mind is only explicitly distinguished from the body in Lockwood, but it was Everett who derived the operation of the record of observations as distinct from the physical entity. Mind-body dualism is the inherent explanatory principle. Physicalism naturally excludes this as meaningless. Everett's resolution of the measurement problem is thus incomprehensible, as Barrett (ibid) describes in detail.

15 Many Minds

The quasi-classical world is the natural assumption, but as demonstrated in experiment by Proietti et al. contradictory observer-dependent realities coexist:

> This result lends considerable strength to interpretations of quantum theory already set in an observer-dependent framework and demands for revision of those which are not. (2019, abs)

Just such a cosmology is inherent in the physics of the Bekenstein (2008) bound, the screen of the holographic universe. This defines a relational ontology, a universe of observer-dependent subsystems. This is literally the inside-view cosmology:

> Perhaps the first person to realize the radical implications of the Bekenstein bound was Louis Crane. He deduced from it that quantum cosmology must be a theory of the information exchanged between subsystems of the universe, rather than a theory of how the universe would look to an outside observer. This was the first step towards the relational theories of quantum cosmologies. (Smolin, 2000, p. 175)
>
> The world must be a network of holograms … the holographic principle is the ultimate realization of the notion that the world is a network of relationships. Those relationships are revealed by this new principle to involve nothing but information. (p. 178)

This is the basis on which relative states operate. The result is a network of coexistent holographic universes that interoperate through communication of information, as when Wigner's friend updates him on the result of the experiment. Relationships are defined by the correlations established by observations.

The result is akin to solipsism. The only determinacy is defined by the mind of the individual, the world hologram. The self is the only reality. As Everett (1956, p. 6) states, solipsism is perfectly in accord with quantum mechanics. He rejects it because of the implicit exclusivity, but this is the nature of each relative state. Each one is an idiosyncratic holographic universe. Many-minds theory is retrodicted:

> Many-minds interpretation of quantum mechanics extends the many-worlds interpretation by proposing that the distinction between worlds should be made at the level of the mind of an individual observer. (Donald, 1998)

For two individuals standing next to each other and making essentially the same observations, their physical realities are of course the same – with regard to that environment at that moment. Their relative states are overlapping classes of superposed worlds, idiosyncratic holographic universes, each one defined solely by that individual mind. The ontology is a 'multi-solipsism'.

16 Conclusion

The incompatible dynamics of quantum mechanics operate at different levels of logical type in the unitary system. There is a dualism of unilateral relative onticities. These are Everett's absolute and relative states. The signature dynamics of these frames of reference operate alternately as described in the standard von Neumann-Dirac formulation. The measurement problem is a category error of logical type.

As Wilczek describes, the missing key is the protagonist of the subjective dynamics, the "observer". As Everett demonstrates, only with respect to the state of the memory, defined as the record of observations, does collapse operate. In humans, the spatially distributed field of information formed by the integrated synthesis constitutes the perceptual reality, the world hologram, the mind in Lockwood's formulation. There is an operational property dualism of body and mind because they operate the different physical dynamics, linear and collapse.

The ontology of Everett's relative state is realised in the physical reality of the world hologram. This is the superposed sum of the class of quasi-classical worlds that instantiate it, a metaworld. It is determinate only where observed because all else is the superposition of all physically possible concomitant states. Collapse on observation is inherent because this changes the definition of the class. The relative state is a second-logical-type phenomenon, which is why it operates differently to the quasi-classical world although it is made of nothing but quasi-classical world.

The holographic universe is the evidence. Determinacy is defined solely by the world hologram, which also delineates the surface of the outer boundary. This observed surface is the intersection of the worlds in the class, the only common determinacy, hence the effect of the holographic universe. As all else is indeterminate, entropy is completely defined by this surface. This is the cosmology of the relative state. The quasi-classical world is the cosmology in the absolute state.

The linear dynamics is the sole causal principle, defining the dynamical behaviour of all physical objects. As this time evolution progresses, the three-dimensional arrangement of matter and energy changes as defined by the wave function of the superposition of the class of worlds. At the point in time where an observation is made, the definition of the class is altered. The collapse of the wave function effectively operates. The holographic universe of the mind is redefined. This is an epiphenomenon of the linear dynamics but it is nonetheless ontic on the inside view.

Wilczek's "observer" is defined by the world hologram. Its perceived interactions with the physical world follow the equations of quantum theory. The operational cycle of the incompatible dynamics is fully accounted for in the physical reality of this self-aware substructure. In this light it may perhaps be legitimately claimed that quantum

theory is defined by the equations of quantum theory, and at last understood.

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Images

“Fission of the relative state on observation” derived from: Biographies are depicted as lines through a cylinder, parallel to the sides, 1989, Lockwood.

“A sequence of quantum mechanical frames of reference” derived from: Worldline, 2005, Wikimedia User: 'SreeBot', http://en.wikipedia.org/wiki/File:Brane-wlwswv.png, Licensed under CC BY-SA 3.0.